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SPATIAL ISSUES IN USER INTERFACE DESIGN FROM A GRAPHIC DESIGN PERSPECTIVE

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INTRODUCTION

The user interface of a computer system is a visual display that provides information about the status of operations on data within the computer and control options available to the user that enable adjustments to these operations. From the very beginning of computer technology the user interface was a spatial display, although its spatial features were not necessarily complex or explicitly recognized by the users. All text and nonverbal signs appeared in a virtual space generally thought of as a single flat plane of symbols.

Current technology of high-performance workstations permits any element of the display to appear as dynamic, multicolor, three-dimensional signs in a virtual three-dimensional space. The complexity of appearance and the user's interaction with the display provide significant challenges to the graphic designer of current and future user interfaces. In particular, spatial depiction provides many opportunities for effective communication of objects, structures, processes, navigation, selection, and manipulation. The following discussion presents issues that are relevant to the graphic designer seeking to optimize the user interface's spatial attributes for effective visual communication.

CURRENT SPATIAL APPROACHES TO USER INTERFACE DESIGN

In all user interfaces, there is a need to present data objects, processes, their status, and structures of various kinds. In addition, the designer of a user interface must determine means for enabling the user to navigate among these objects, to select them, and to manipulate them in various ways. Influenced by the introduction of the Xerox Star and Apple Macintosh computers in the early 1980s, computer graphics programmers have emphasized recently the multiwindowed desktop metaphor as a basis for appearance and interaction.

The desktop spatial metaphor assumes that the viewer is looking at a flat background, with one or more rectangular windows in front of (or on top of, according to the implied orientation of the conventional horizontal desktop) the background plane. The windows may tile the foreground or may overlap in various ways. Icons, or other small signs, standing for objects, processes, structures, or data, can appear in the background plane or in the window planes. In addition to windows, various menus and dialogue boxes can appear within windows or in front of any or all the windows. In front of all of these elements, cursors may float across the visual field. Any of the windows or the background may contain graphics images that depict a deep three-dimensional space.

The space is designed as a shallow layering of foreground, middle ground, and background, reminiscent of traditional shallow spatial compositions in modern painting (Loran, 1963; Berkman, 1949). This multiple-layered composition is also reminiscent of layered cartoon animation cells, a kind of two-and-one-half-dimensional space, as it is sometimes called.

Certain visual enhancements to the depiction of objects in the space are typically used to help the viewer understand the spatial composition. These include the following techniques: (1) drop shadows, (2) beveled edges, (3) highlighting and lowlighting, and (4) shrinking and growing.

For example, drop shadows, typically directed to the lower right, help to convey the layering of windows, pull-down or pop-up (more explicitly, pop-in-front-of) menus, or dialogue boxes. In some user interfaces, icons, buttons, switches, menu elements, or entire rectangles of menus, dialogue boxes, or windows, may be given beveled sides so that they appear to protrude toward the viewer. Sometimes their sides are colored with varying levels of gray-value to strengthen the illusion of three-dimensional form and a light source, often implied to be located at the upper left. In addition, entire windows or other areas of the screen may be highlighted to come forward to the viewer, while other windows may be lowlighted to suggest that they are farther back in space. Elements sometimes change their size and appearance; for example, an icon may enlarge to become a window. This is often shown as a spatial growth in two dimensions, which contributes to the illusion of overlapping elements.

These techniques are similar to those employed by designers to enhance information-oriented graphics, such as the design of charts, maps, and diagrams (Herdeg, 1981). They have distinct communication value from a graphic design point of view. These spatial qualities accomplish the following:

1. Distinguish various elements on the screen
2. Help the viewer to recognize particular classes of objects
3. Add charm or appeal to the design style of the user interface
4. Convey corporate or product design conventions

Besides the traditional desktop, the image of the control panel is also used in some user interfaces, in which part or all of the screen may convey one or more flat panels with switches, knobs, and other control devices. A variant on the desktop is the giant desktop in which the viewer sees one part of the background through a viewport and must use scrolling devices to examine other areas. Another variant of the desktop might be called the multiple desktop in which the viewer may move from desktop to desktop by zooming, sudden cuts or pops, or other visual techniques. A memorable approach using sound cues to aid spatial cues was presented by the MIT Architecture Machine Group's spatial data management system (Bolt) in the 1970s in which the background plane zoomed toward the viewer with an audible whoosh as the viewer suddenly dropped onto a layer below with an audible popping sound. Apple's Hypercard and similar hypertext products generally extend the notion of the screen as a set of planes.

OTHER SPATIAL METAPHORS

Programmers have experimented with other spatial metaphors to facilitate human-computer communication. One alternative is the metaphor of architecture. The Learning Company, for example, has offered since the early 1980's an award-winning children's game called Rocky's Boots, programmed by Warren Robinet, that provides the viewer with the cognitive model of a set of rooms, each with entrances and exits. The screen display communicates a set of spaces linked by the topology of familiar architectural experiences. Another approach was taken in the work of Gould and Finzer (1984). They proposed a cognitive model of theater, in which the entire display was depicted as a stage set. This approach implies a deeper spatial metaphor than the traditional desktop.

Other approaches are possible as workstations provide ever greater capabilities to manipulate three-dimensional reality. For example, at the Microcomputer Technology Consortium, Austin, TX, the Semnet project proposed a deep space for viewing and manipulating a semantic network. Another example is the head-mounted display project at NASA Ames Research Center, Moffett Field, CA, begun by Michael McGreevy in which the viewer sees a full three-dimensional environment for all appearance and interaction imagery. With the advent of screens using Adobe's PostScript picture definition language, as in Sun and Next's products, it is possible to display screen metaphors using the building or even the urban environment as a basis for spatial communication of the user interface. All that is required is a set of familiar symbols, a familiar spatial arrangement, and a familiar ritual for interacting with them. Videogames in the entertainment industry have employed routinely a variety of spatial idioms, including rooms, buildings, and landscapes to convey the field of action.

FUTURE DIRECTIONS

Within the entertainment field and within current user interface design, future directions of spatial representation are already emerging. Two areas of emphasis are depictions of deep space and depictions of three-dimensional objects.

In commercial cable and broadcast television and in the film industry (Morgan and Symmes, 1983), there has been a continuous fascination with depictions of deep space. The title sequence of the *Star Wars* movie, in which text moves backwards at a steep angle from the viewer, inherits a tradition from older films. Today, it is routine for evening news programs, weather reports, movie introductions, and station breaks to feature photographic images, typography, and other elements of flying logos swirling about within deep spatial representations.

All depictions of surfaces, projected light and cast shadows, and dynamic objects in computer graphics are currently very expensive to produce, requiring significant budgets, time, personnel, and equipment. However, the creators of sophisticated animation software, like Wavefront, are broadening the base of hardware and user groups, so that the industry in general will be nurtured with more powerful spatial display and image rendering capabilities. Eventually these capabilities will be routinely available for widespread use in the depiction of user interface components.

Even without expensive workstations, it is possible to display three-dimensional objects as components of the user interface. A current music editing software package on the Commodore Amiga, for example, shows solid pillars and an arch framing the sides and top of the controls for musical composition.

SPATIAL DEPTH CUES

The use of spatial relations to depict the elements of the user interface suggests that designers may find it useful to review Gibson's list of visual cues that establish the perception of space. These perspective experiences are summarized in Hall's book, *The Hidden Dimension* (1982). Briefly, the taxonomy of spatial depth attributes is the following:

Position

- Texture: gradual increase in density of texture of a receding surface
- Size: gradual decrease in size of distant objects
- Linear perspective: parallel lines receding to vanishing points

Parallax

- Binocular: an image with shifted object locations for each eye
- Motion: objects moving at uniform speeds appear slower if distant

Other Cues

- Aerial perspective: increased haziness and change in color and contrast with distance
- Blur: objects nearer or more distant than the focal plane appear fuzzy
- Vertical location in the visual field: lower part appears nearer, the upper farther
- Shift in double imagery: in distant views, nearer objects have doubling gradient
- Completeness or continuity of outline: nearer objects overlap farther objects
- Shift of light and dark: abrupt changes appear as edges, gradual as roundness

Some, but not all, of these cues are currently employed within user interfaces in order to create convincing spatial scenes. As user interfaces become more visually complex, designers will utilize more of these depth cues and will consequently need to determine user interface spatial-depiction attributes in a systematic manner.

RELATION TO INDUSTRIAL OR PRODUCT DESIGN

In addition to more complex spatial metrics and spatial metaphors that unite objects in a continuous space (either the familiar Euclidian, the less familiar non-Euclidian, or even strangely warped topologies), increased sophistication of spatial display also means that the individual components of the user interface can take on elaborate internal spatial structures. All of these typical user interface components, such as windows, menus, dialogue boxes, control panels, icons, and cursors, can acquire significant plastic form attributes.

Consider the following examples of possible attribute sets:

Windows with solid extruded shapes for title area and scroll bars

Scroll bars appearing as translucent round columns with the symbol for the visible portion of the screen represented as a solid tube sliding within them

Windows as the front surface of rectangular parallelepipeds, with regular conventions of semantics assigned to the other faces of the solid

Icons as three-dimensional blocks with internal moving parts, whose surface characteristics (metallic, rough, warm, etc.) or interlocking features might contribute to their denotation

Cursors as large, three-dimensional portraits whose pointing fingertips focus the user's attention on a particular screen component while their facial expression conveys important connotative content

At this point, user interface designers would benefit by examining the history and current practice of professionals in graphic design, architecture, industrial design, and product design (Herdeg, 1981; Jencks, 1982; Pevsner, 1963; *Industrial Design Magazine*). In contemporary industrial design, for example, one finds a dialectic taking place between minimalist, Apollonian approaches (International style, Bauhaus style, etc.) in which all objects have a highly consistent, limited selection within attribute space, and the more exuberant, Dionysian approaches (Memphis style, product semantics style, post-modern style) in which eclectic, exotic, wildly different attribute selection reigns. User interface design at this point leaves the engineering domain and enters the world of aesthetic styling, which contributes significantly to the marketing of products worldwide. It is also in this realm of the user interface as plastic, shaped artifact, that corporate design or product design standards influence the three-dimensional attribute selections (Marcus, 1984, 1985).

As user interface design takes on more spatial attributes, the collection of symbols in space take on cultural characteristics far more complicated than the basic issues of ergonomic design. It would seem reasonable for user interface designers to consider the discipline of proxemics (Hall, 1963), the science of interpersonal space, for guidance in user-computer spaces.

SUMMARY

Aided by advancing technology and spurred both by the need for depicting increasing amounts of data and functions and by market interest, user interface design is taking on more spatial characteristics. User interface graphic designers will need to coordinate, unify, and optimize for communication effectiveness a very broad, deep hierarchy of spatial attributes for every component of the interface. Lessons can be learned by examining the theory and practice of professionals in other disciplines who have also worked with complex spatial structures, both as matters of geometry and as cultural artifacts. The reading list is intended as an initial guide to the literature of these allied disciplines. The scope and rate of change within user interface design promises to offer an exciting opportunity and test of skill for the human mind in shaping three-dimensional forms for pictorial communication.

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